# Forecasting Development

Forecasting Research Technical Report No. 392

Summary of tropical cyclone activity and forecasts in the 2001 northern hemisphere season

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# FORECASTING RESEARCH

# TECHNICAL REPORT NO.392

## SUMMARY of TROPICAL CYCLONE ACTIVITY and FORECASTS in the 2001 NORTHERN HEMISPHERE SEASON

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## 1. INTRODUCTION

A summary of tropical cyclone activity in the northern hemisphere for the 2001 season is presented below together with an assessment of the performance of the Met Office global model in predicting the tracks of these tropical cyclones.

Tropical cyclones are experienced in the North Pacific, North Atlantic and North Indian Oceans and nearby tropical seas. For the purpose of tropical cyclone verification the northern hemisphere is divided in to four basins; the North-West Pacific (west of 180°E to the Malay Peninsula), the North-East Pacific (east of 180°E), the North Atlantic and the North Indian Ocean (west of the Malay Peninsula). Mean error statistics for each basin are presented together with a table of statistics for the whole northern hemisphere. The global model produces a 6-day forecast every 12 hours. Verification is performed at 24 hour intervals up to forecast time T+120.

The global model resolution in operation during the season was 0.83°x 0.55°x 30 levels. This is equivalent to a horizontal resolution of 93km x 62km at the equator. The tropical cyclone verification scheme identifies the centre of a tropical cyclone in the model by locating a local maximum of relative vorticity at 850hPa. A surface fitting technique is used to locate the centre accurately.

The terms used in the statistics tables are explained below :-

Possibly verified - No. of forecasts fulfilling requirements 1, 2 & 4 below.
Detection Rate - Percentage of possibly verified forecasts which also fulfil requirement 3 below.
Mean DX - Mean of positional errors in the East-West direction.
Mean DY - Mean of positional errors in the North-South direction.
Mean AT - Mean of positional errors in the Along Track direction.
Mean CT - Mean of positional errors in the Cross Track direction.
Skill - Percentage skill of model against CLIPER.
Mean DPE - Mean of direct positional errors.
All errors are measured in kilometres except where indicated.

(*) 1. Observed maximum wind at least 31 knots at the verifying time.
2. Forecast tropical cyclone centre equatorwards of 45 degrees.
3. Forecast tropical cyclone centre relative vorticity above a critical limit for verification ($0.7 \times 10^{-4}$ per second).
4. Observation within 6 hours of verifying time present for use in verification.

Forecast skill is defined as:-
(CLIPER DPE - Model DPE) / CLIPER DPE x 100%

Positive skill indicates the model forecast is better than CLIPER.
Negative skill indicates the CLIPER forecast is better than the model.

A diagrammatic explanation of other error statistics and their sign conventions can be found in Appendix A. Full details of the TC verification scheme can be found in ***NWP Gazette, Vol.1, No.2, December 1994***.

Advisory positions from JTWC Hawaii, NHC Miami and CPHC Honolulu are used as verifying observations of storm location when track verification is carried out immediately after a storm has ended. Best track data from these centres has been obtained for this season's storms and the track forecasts verified again. Statistics for verification against best-track observations are presented in detail. Some statistics for verification against real-time observations are included for the purposes of a comparison and are denoted 'RT'. Some mean error statistics for last season are also included for the purposes of a comparison. Forecast tracks are only verified when a depression reaches tropical storm status.

## 2. TROPICAL CYCLONE ACTIVITY

| | NWP | NEP | NAT | NI | TOTAL |
|---|---|---|---|---|---|
| Tropical Depressions (<34 knots) | 4(8) | 4(2) | 2(4) | 0(0) | 10(14) |
| Tropical Storms (>34 knots, <64 knots) | 8(10) | 7(13) | 6(6) | 4(2) | 25(31) |
| Hurricanes/typhoons (>64 knots) | 20(15) | 8(6) | 9(8) | 1(2) | 38(31) |
| Total | 32(33) | 17(21) | 17(18) | 5(4) | 71(76) |

Categories assigned based on 1-minute averaged winds

Basin name abbreviations:- NWP = North-West Pacific (west of 180°E)
NEP = North-East Pacific (east of 180°E)
NAT = North Atlantic
NI= North Indian

The number in brackets indicates the figure for the 2000 season.

## 3. SUMMARY OF ALL NORTHERN HEMISPHERE STORMS

### 3.1 North-West Pacific Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 287 | 230 | 183 | 141 | 106 | 74 |
| Detection Rate (%) | 100 | 100 | 100 | 95 | 92 | 80 |
| Mean DX | -4 | -21 | -82 | -159 | -234 | -397 |
| Mean DY | 2 | 23 | 33 | 4 | -29 | -135 |
| Mean AT | -3 | -8 | -14 | -52 | -117 | -217 |
| Mean CT | -4 | -16 | -72 | -140 | -204 | -255 |
| Mean Skill (%) | ***** | 15 | 29 | 38 | ***** | ***** |
| 2000 Skill (%) | ***** | 14 | 29 | 33 | ***** | ***** |
| Mean DPE | 41 | 132 | 253 | 357 | 523 | 763 |
| * 2000 DPE | 43 | 141 | 267 | 401 | 496 | 623 |
| RT DPE # | 37 | 132 | 253 | 359 | 528 | 768 |

* DPE for all North-West Pacific storms in 2000 season
# DPE in 2001 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 1.

Activity in this basin was greater than last year in terms of verifiable forecasts. There were five more typhoons than in the 2000 season. Forecast errors were slightly lower than in 2000 up to T+72, but slightly higher at longer ranges. Skill against CLIPER was similar to 2000 at T+24 and T+48, but higher at T+72. There were slight slow and left-of-track biases overall.

Figs. 2 and 3 show forecast errors and skill scores for the last few seasons.

## 3.2 North-East Pacific Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 117 | 87 | 60 | 40 | 28 | 17 |
| Detection Rate (%) | 100 | 100 | 98 | 88 | 75 | 71 |
| Mean DX | 6 | -3 | 0 | 52 | 170 | 254 |
| Mean DY | -4 | 3 | -44 | -114 | -158 | -122 |
| Mean AT | -8 | -18 | -64 | -145 | -260 | -275 |
| Mean CT | 3 | 0 | -51 | -79 | -23 | 48 |
| Mean Skill (%) | ***** | 14 | 22 | 15 | ***** | ***** |
| 2000 Skill (%) | ***** | 25 | 33 | 39 | ***** | ***** |
| Mean DPE | 35 | 108 | 190 | 290 | 386 | 360 |
| * 2000 DPE | 31 | 107 | 184 | 250 | 342 | 420 |
| RT DPE # | 31 | 110 | 199 | 297 | 389 | 361 |

* DPE for all North-East Pacific storms in 2000 season
# DPE in 2001 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 4.

There was less activity in this basin in 2001 than 2000, although there were more hurricanes. Forecast errors were near to or below last season's values at all times exceptT+72 and T+96. The model's skill over CLIPER was lower than in 2000 and 1999. There was a slight slow bias in forecasts and the detection rate was relatively poor at longer forecast ranges after very good performance in 2000.

Figs. 5 and 6 show forecast errors and skill scores for the last few seasons.

## 3.3 North Atlantic Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 132 | 99 | 71 | 48 | 36 | 26 |
| Detection Rate (%) | 100 | 100 | 99 | 94 | 86 | 88 |
| Mean DX | -3 | -20 | -33 | -83 | -59 | -40 |
| Mean DY | 5 | 41 | 84 | 75 | 78 | 180 |
| Mean AT | -11 | -41 | -56 | -48 | 15 | -81 |
| Mean CT | -5 | 3 | -11 | -64 | -35 | -42 |
| Mean Skill (%) | ***** | 37 | 46 | 61 | ***** | ***** |
| 2000 Skill (%) | ***** | 18 | 38 | 43 | ***** | ***** |
| Mean DPE | 34 | 134 | 256 | 352 | 366 | 473 |
| * 2000 DPE | 22 | 144 | 247 | 349 | 412 | 520 |
| RT DPE # | 35 | 134 | 256 | 351 | 366 | 474 |

* DPE for all North Atlantic storms in 2000 season
# DPE in 2001 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 7.

Activity was more or less the same in 2001 as in 2000. Forecast errors were fairly similar as well, with slightly lower errors at T+96 and T+120. However, skill against CLIPER was higher than in any previous season. There were no significant biases in forecasts.

Figs. 8 and 9 show forecast errors and skill scores for the last few seasons.

### 3.4 North Indian Basin Storms

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 24 | 14 | 10 | 8 | 6 | 4 |
| Detection Rate (%) | 100 | 100 | 100 | 75 | 83 | 75 |
| Mean DX | -5 | 27 | -24 | -85 | -177 | -169 |
| Mean DY | 8 | 44 | 132 | 156 | 145 | -7 |
| Mean AT | -18 | -23 | 5 | 23 | 8 | -91 |
| Mean CT | 22 | -21 | -81 | -89 | -255 | -155 |
| Mean Skill (%) | ***** | -21 | -31 | -26 | ***** | ***** |
| 2000 Skill (%) | ***** | -14 | 5 | ***** | ***** | ***** |
| Mean DPE | 48 | 142 | 275 | 351 | 358 | 265 |
| * 2000 DPE | 61 | 145 | 251 | 498 | ***** | ***** |
| RT DPE # | 30 | 144 | 270 | 343 | 358 | 259 |

* DPE for all North Indian storms in 2000 season
# DPE in 2001 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 10.

There was slightly more activity in 2001 than 2000 and some longer range forecasts were verified. Only at T+48 were forecast errors slightly higher than last season. However, skill scores against CLIPER were poorer than for many years. There was a left-of-track bias in forecasts at longer ranges.

Figs. 11 and 12 show forecast errors and skill scores for the last few seasons.

## 3.5 Combined Statistics for whole Northern Hemisphere

Table of Mean Error Statistics

| | T+0 | T+24 | T+48 | T+72 | T+96 | T+120 |
|---|---|---|---|---|---|---|
| Possibly Verified | 560 | 430 | 324 | 237 | 176 | 121 |
| Detection Rate (%) | 100 | 100 | 99 | 93 | 88 | 80 |
| Mean DX | -2 | -15 | -54 | -108 | -143 | -225 |
| Mean DY | 2 | 24 | 33 | 4 | -19 | -55 |
| Mean AT | -7 | -18 | -32 | -64 | -106 | -188 |
| Mean CT | -2 | -9 | -55 | -114 | -147 | -164 |
| Mean Skill (%) | ***** | 21 | 32 | 42 | ***** | ***** |
| 2000 Skill (%) | ***** | 17 | 32 | 37 | ***** | ***** |
| Mean DPE | 38 | 128 | 243 | 345 | 468 | 629 |
| * 2000 DPE | 38 | 134 | 244 | 357 | 440 | 551 |
| RT DPE # | 35 | 128 | 244 | 347 | 471 | 632 |

* DPE for all Northern hemisphere storms in 2000 season
# DPE in 2001 calculated using real time observations as opposed to best track.

Comments :
Forecast errors for the whole northern hemisphere in 2001 were similar to those for 2000 up to T+72 and slightly higher at T+96 and T+120. Overall, errors were lower than in any year prior to 1999. Skill scores against CLIPER were slightly higher than in 2000 at T+24 and T+72. There was a slight slow and left-of-track bias in forecasts overall. Detection percentages were not so good as in 2000, with only 80% of T+120 forecasts being verifiable.

There was very little difference between forecast positional errors derived using real time observations and those derived using best track observations.

Figs. 13 to 16 show forecast errors, skill scores, along and cross track errors over the last few seasons.

## Further Tropical Cyclone Information

The Met Office pages on the World Wide Web contain information on tropical cyclone forecasting at the Met Office. Monthly bulletins of tropical cyclone activity and forecasts are held together with observed and forecast track information of recent storms, track prediction error statistics, lists of names, images, movies and photographs and details of advances made in tropical cyclone track prediction at the Met Office. Real time tropical cyclone forecast guidance is also now available.

The Met Office web site is:- **http://www.metoffice.com**
Tropical Cyclone information can be found on the home page under the **"World Weather News"** heading.

Seasonal summaries of tropical cyclone activity and forecasts have been issued since the 1994-5 southern hemisphere season. To obtain these or any further information on tropical cyclone forecasting at the Met Office email **tropical_cyclones@metoffice.com**. Past seasonal reports can also be found on-line under the "Forecast Verification" section of the tropical cyclone pages on the Met Office web site.

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## Acknowledgements

CLIPER models for various basins were supplied by Mr.S.Lord, NMC, Washington, USA and Mr.C.Mauck, FNOC, Monterey, USA.
GrADS software used to produce track plotting charts was supplied by Mr.S.Lord and Dr.M.Fiorino.
Best track observations for the northern hemisphere were obtained from the National Hurricane Center, Miami and the Joint Typhoon Warning Center, Hawaii.


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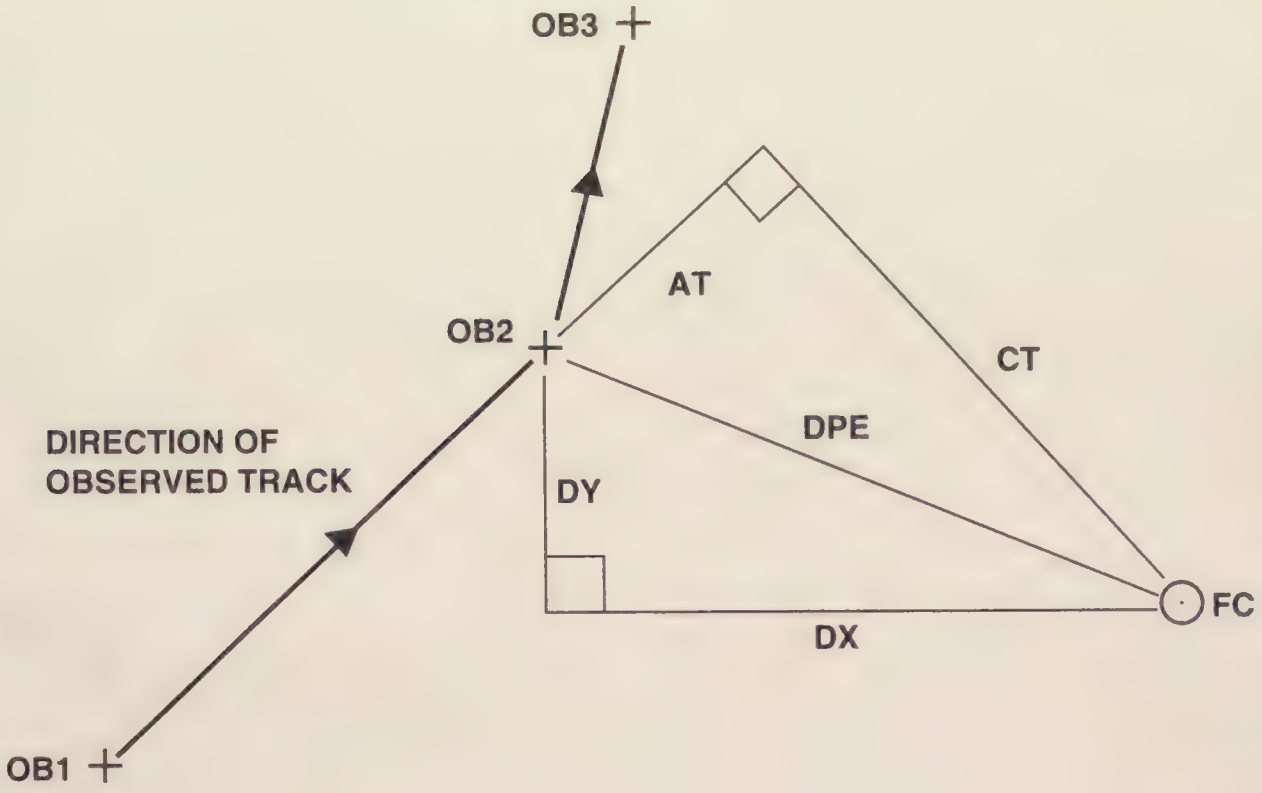
# APPENDIX A

## Diagrammatic Explanation of Forecast Errors



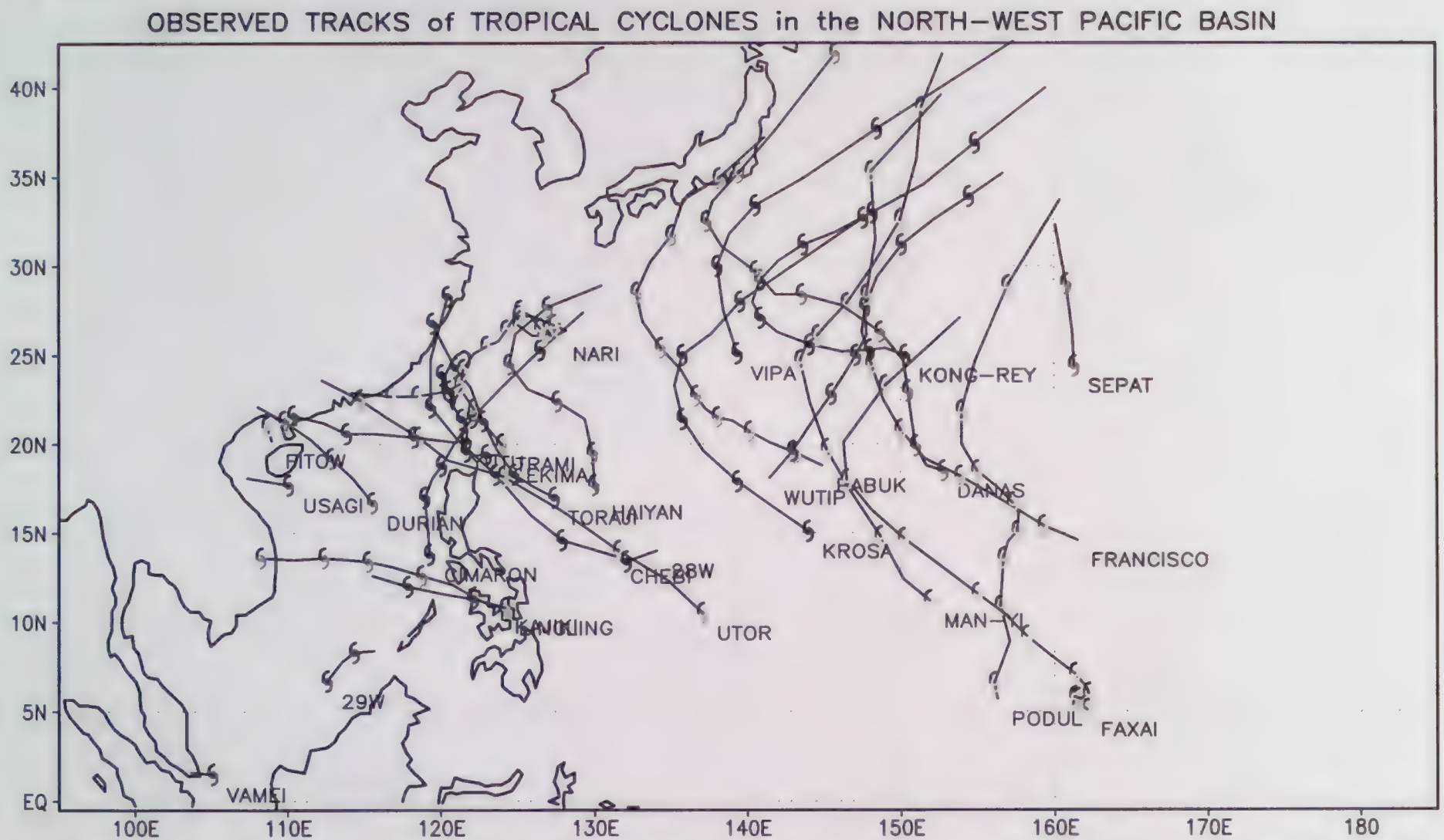

OB1-3 : Observed positions
FC : Forecast position verifying against observation OB2
DPE : Direct positional error
DX : Error in the East-West direction
DY : Error in the North-South direction
AT : Error in the Along Track direction
CT : Error in the Cross Track direction

All errors are measured in kilometres

### Sign Conventions

DPE values are always positive.
DX errors are positive if the forecast position lies eastwards of the observed position.
DY errors are positive if the forecast position lies polewards of the observed position.
AT errors are positive if the forecast position lies ahead of the observed position along the tropical cyclone track.
CT errors are positive if the forecast position lies right of the observed track in the northern hemisphere and left of the observed track in the southern hemisphere.

Figure 1




| | | | | |
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| KONG-REY 20010722 | YUTU 20010724 | TORAJI 20010727 | MAN-YI 20010802 | USAGI 20010810 |
| PABUK 20010815 | WUTIP 20010828 | SEPAT 20010828 | FITOW 20010831 | DANAS 20010904 |
| NARI 20010907 | VIPA 20010918 | FRANCISCO 20010920 | LEKIMA 20010923 | KROSA 20011004 |
| HAIYAN 20011013 | PODUL 20011020 | LINGLING 20011107 | 28W 20011121 | 29W 20011121 |
| KAJIKI 20011206 | FAXAI 20011215 | VAMEI 20011227 | | |

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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Figure 2

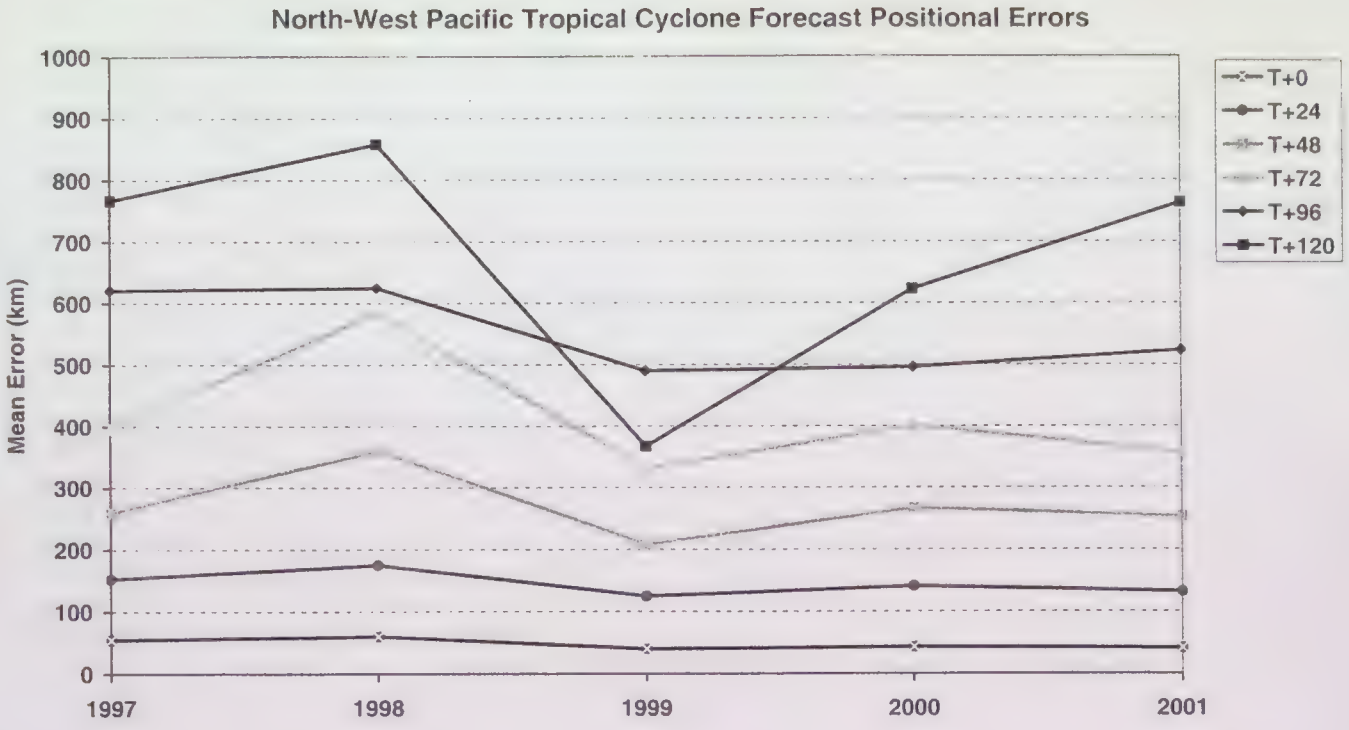


Figure 3

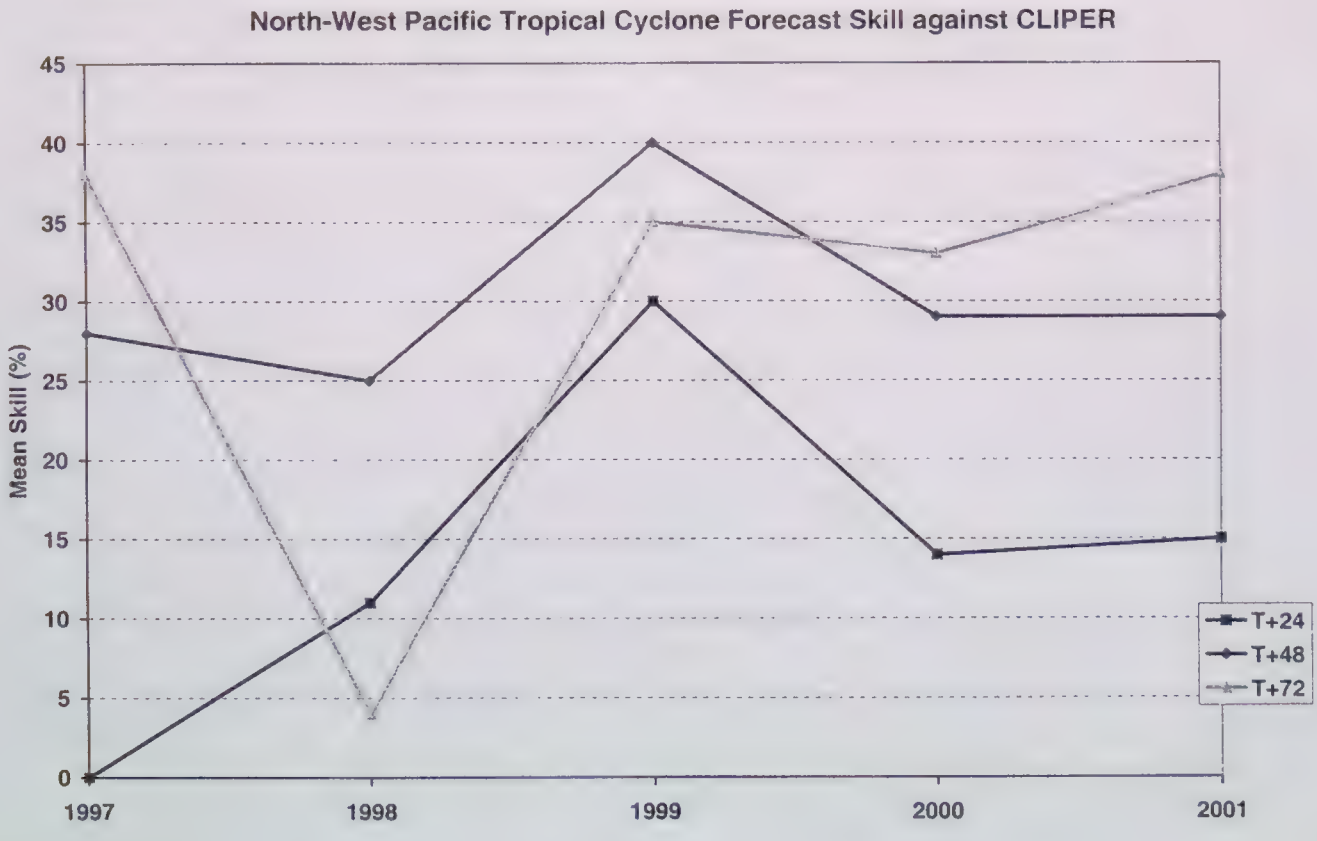

Figure 4

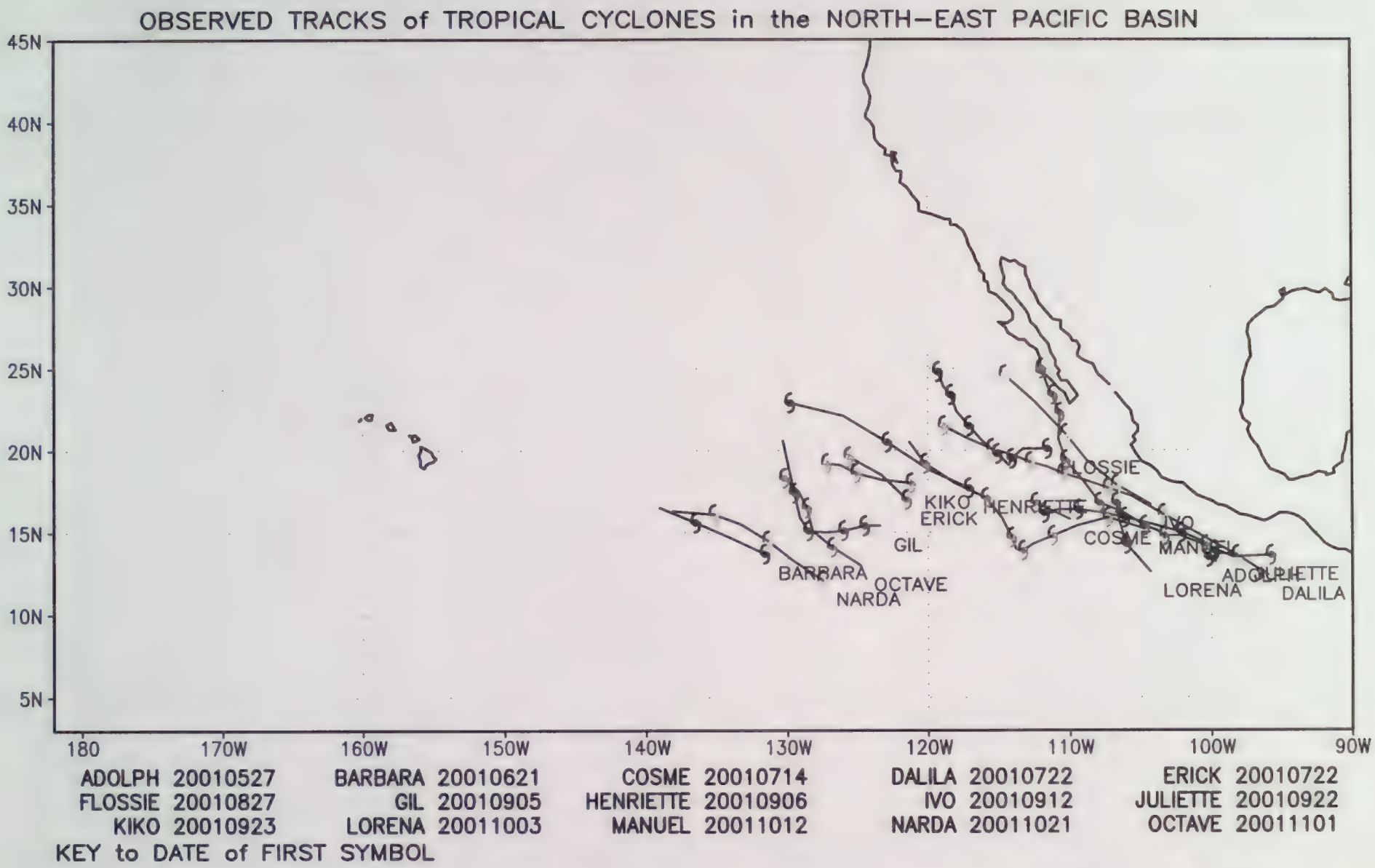


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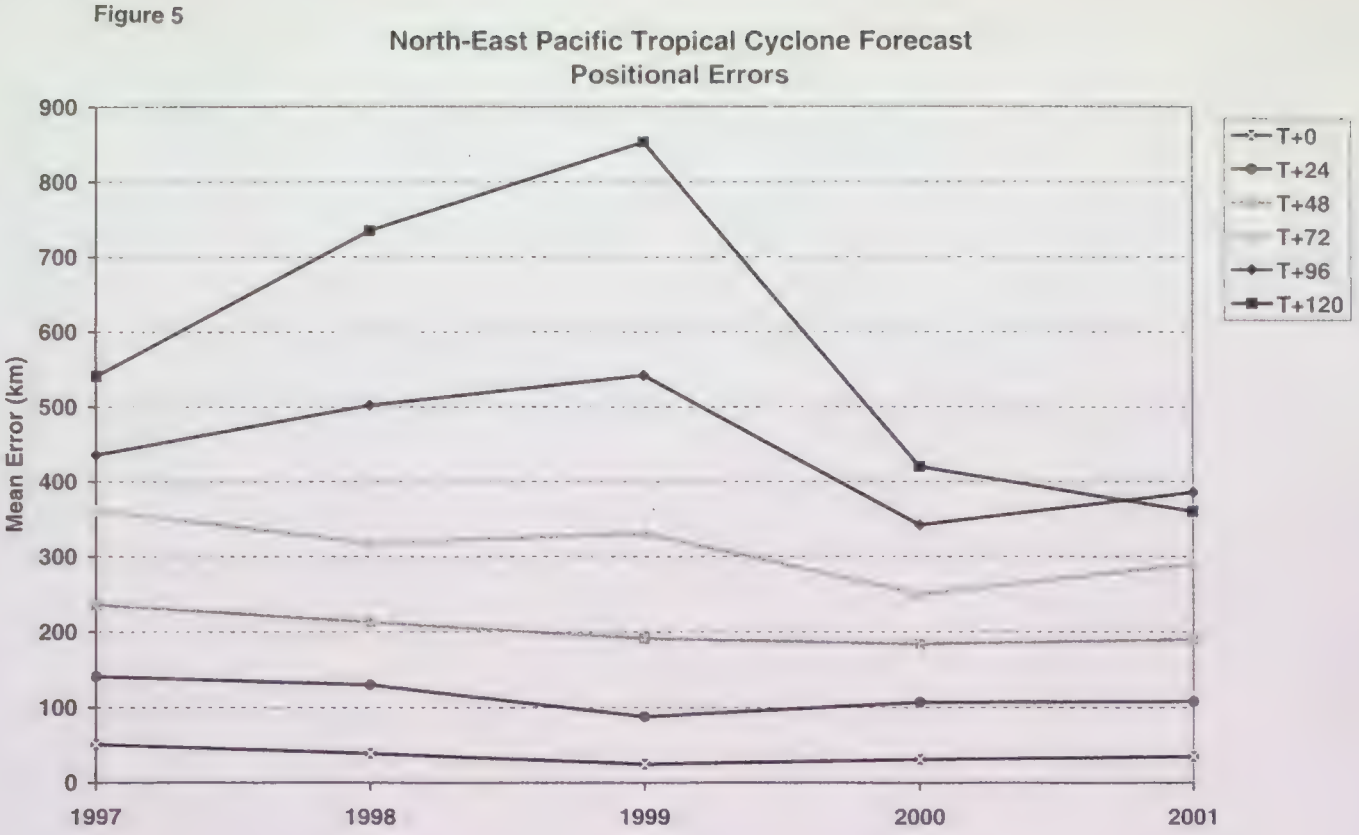
Figure 5

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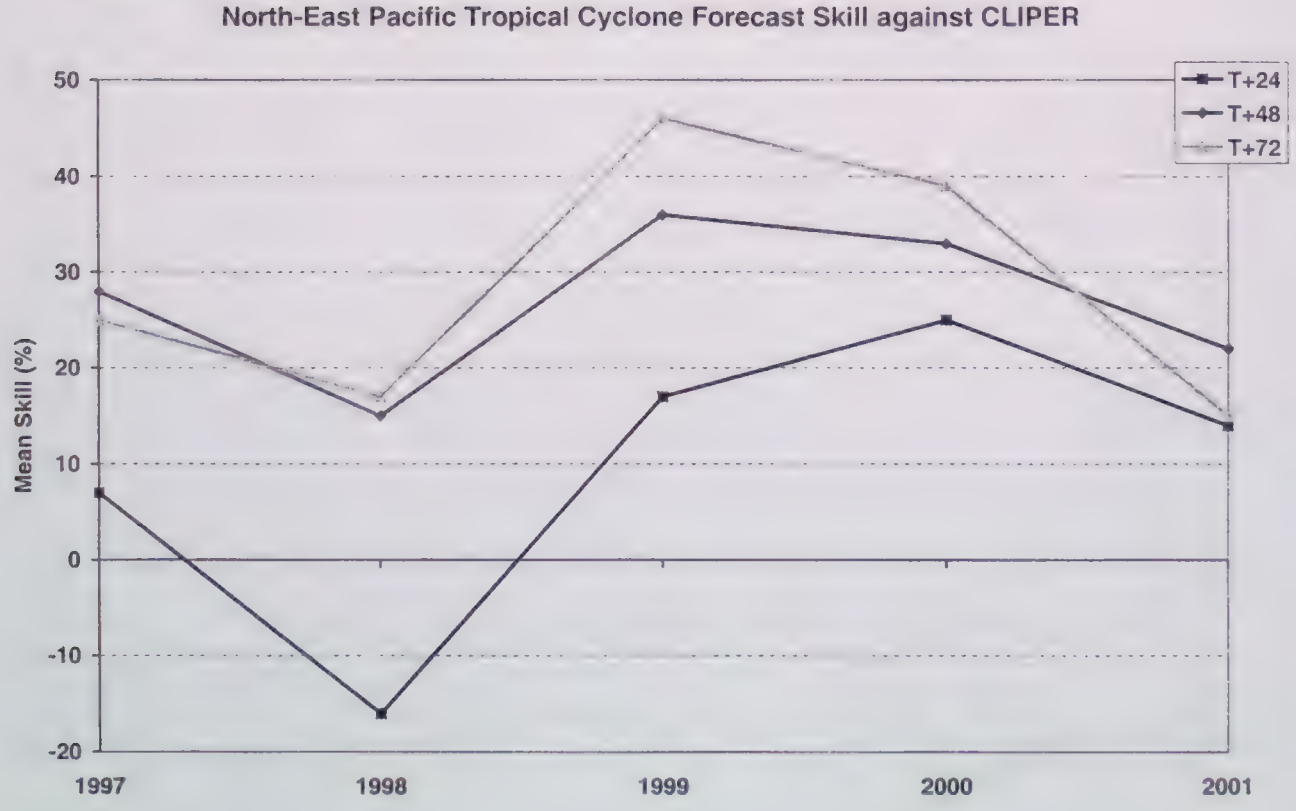
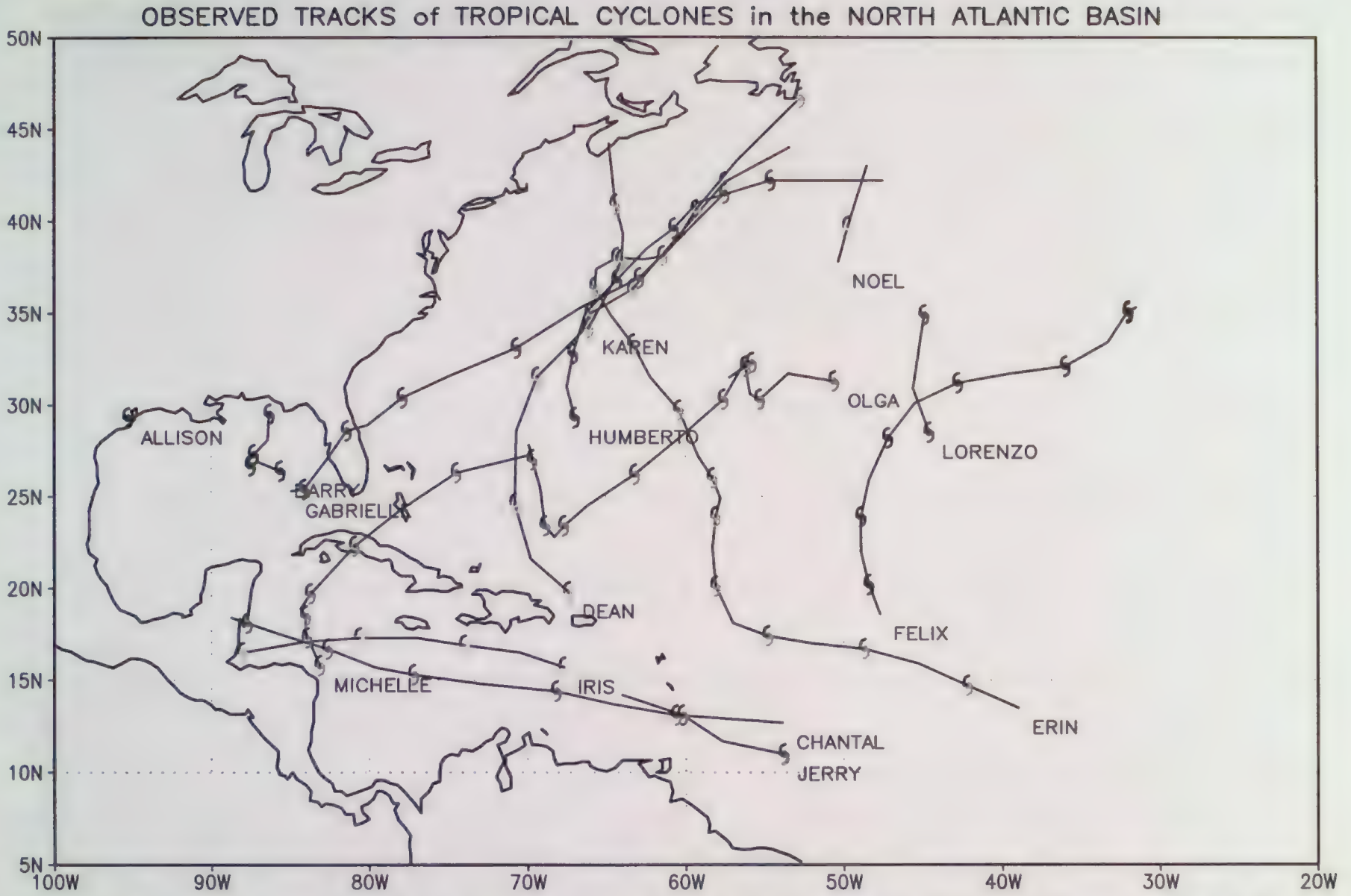


Figure 7




| | | | | |
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| FELIX 20010912 | GABRIELLE 20010914 | HUMBERTO 20010923 | IRIS 20011006 | JERRY 20011007 |
| KAREN 20011013 | LORENZO 20011030 | MICHELLE 20011101 | NOEL 20011106 | OLGA 20011125 |

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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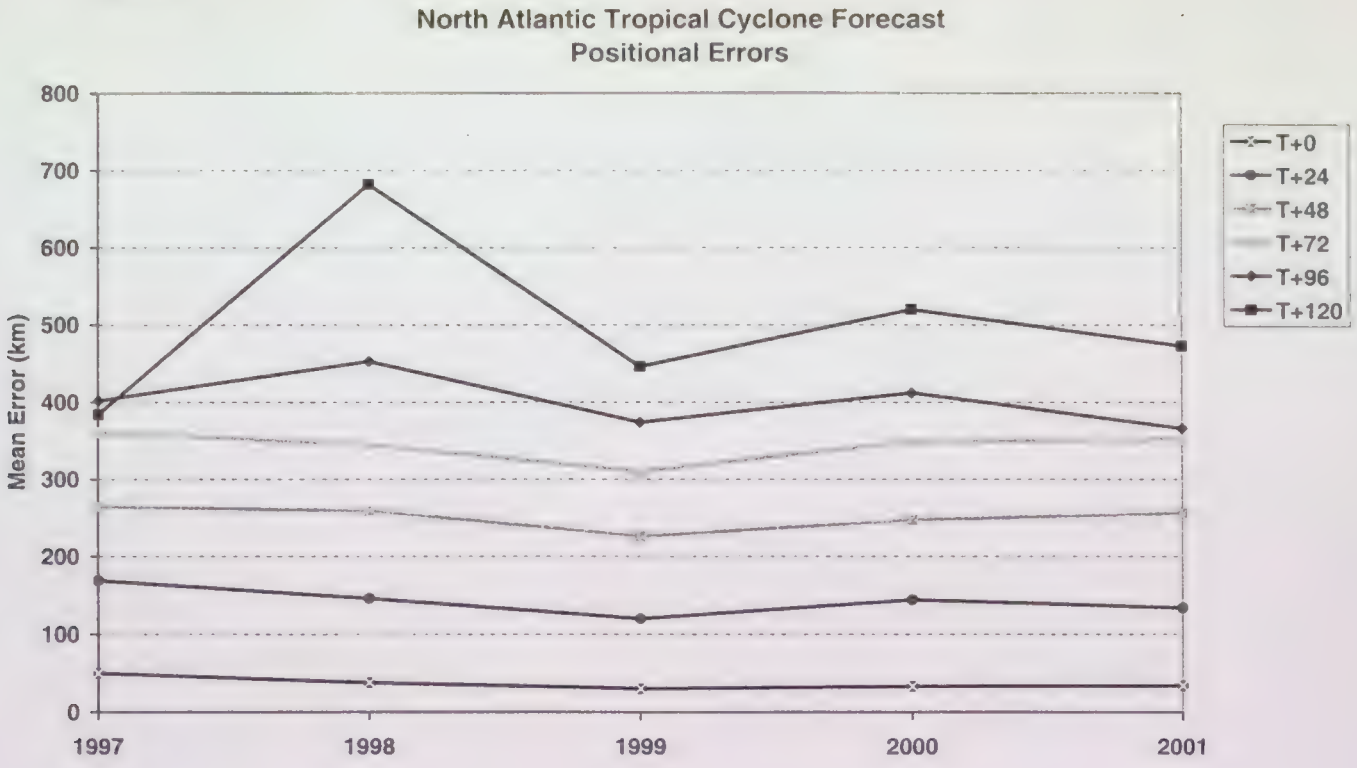
Figure 8

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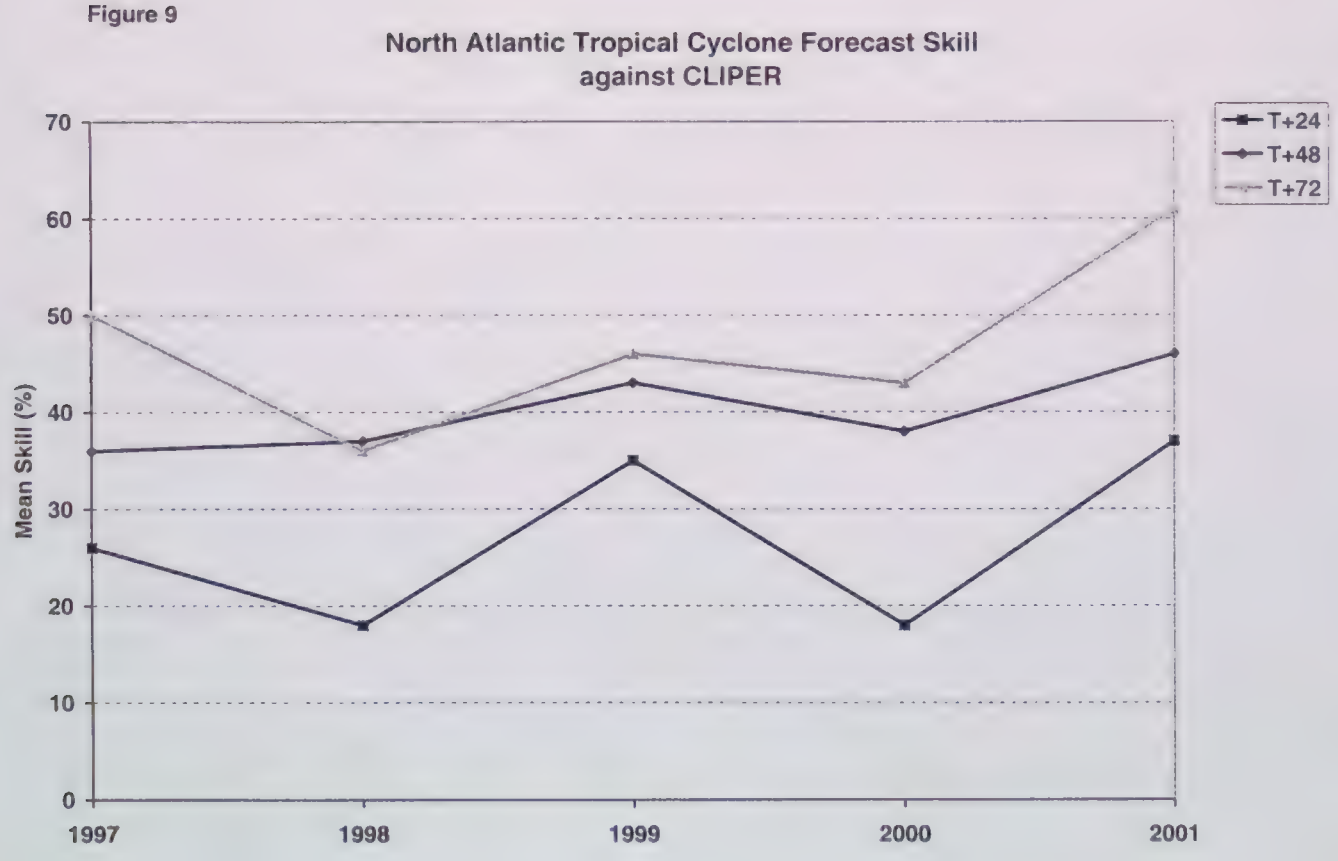
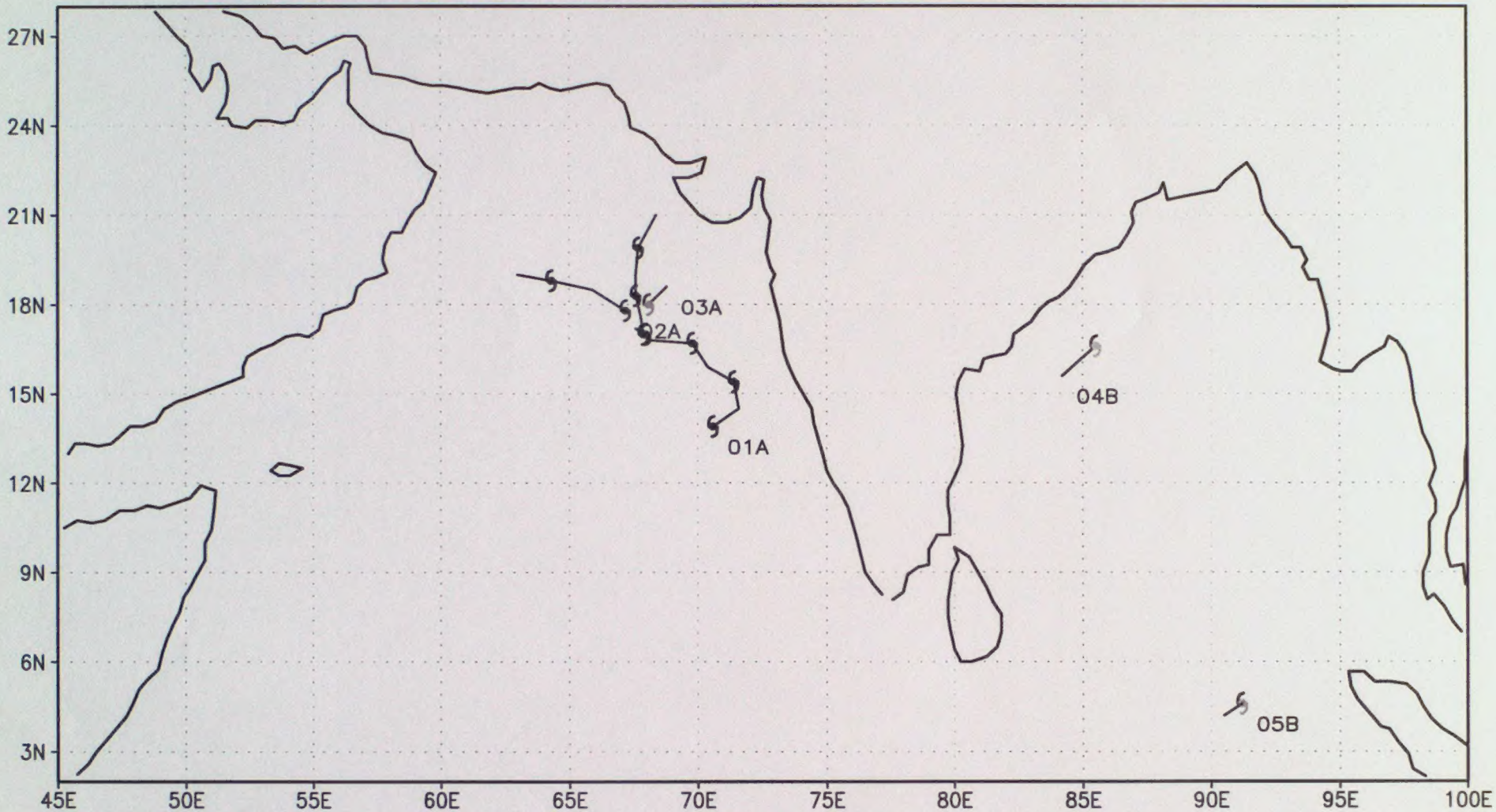


Figure 10

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH INDIAN BASIN

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24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

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Figure 11

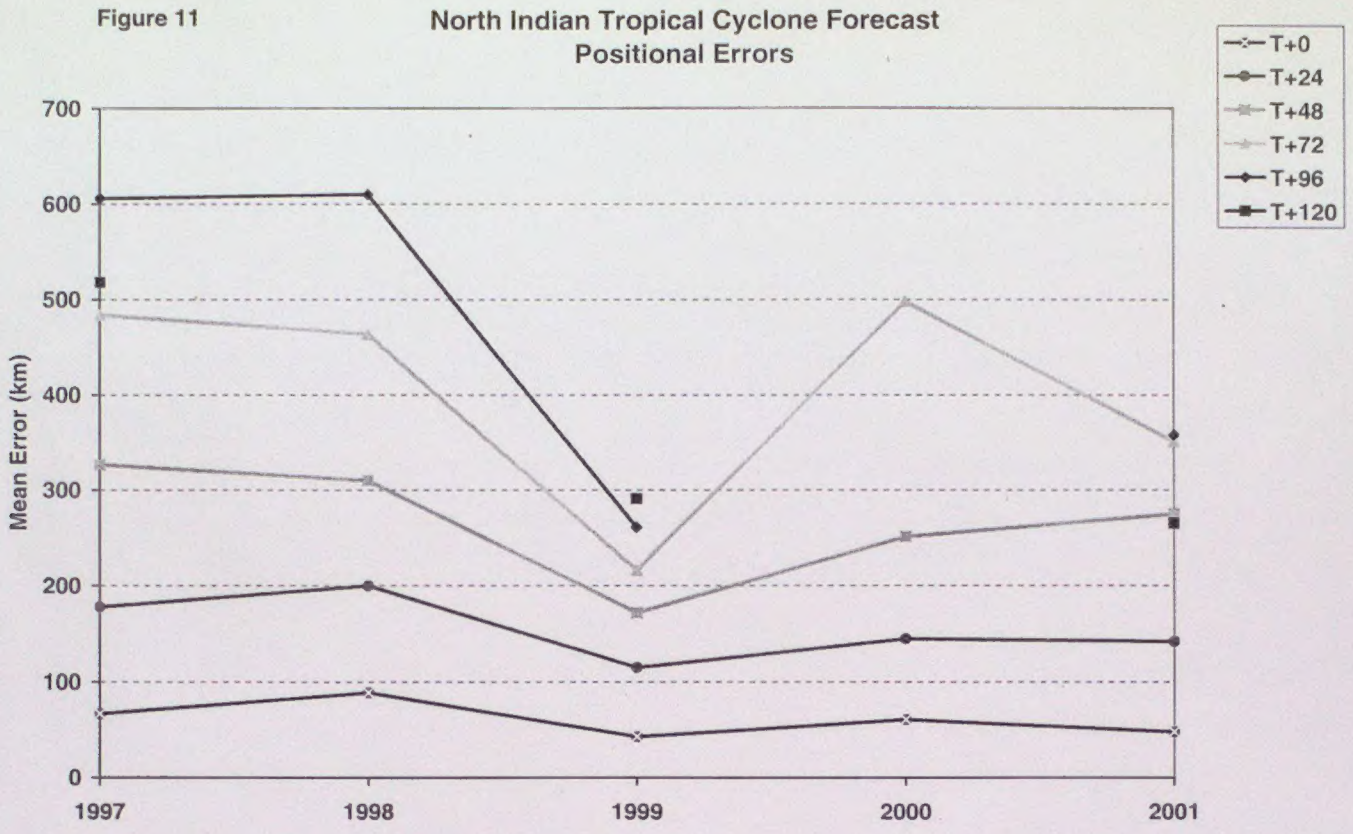



Figure 12

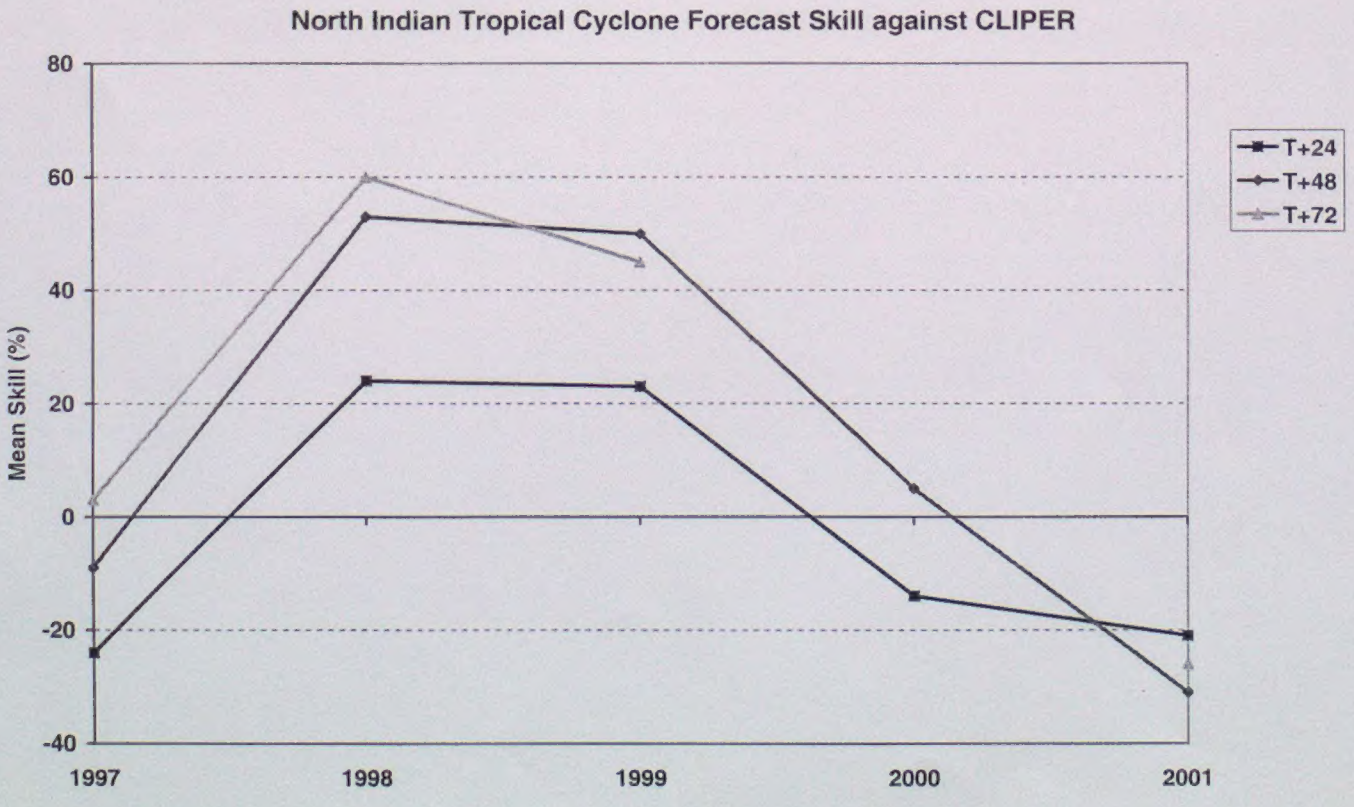


Figure 13

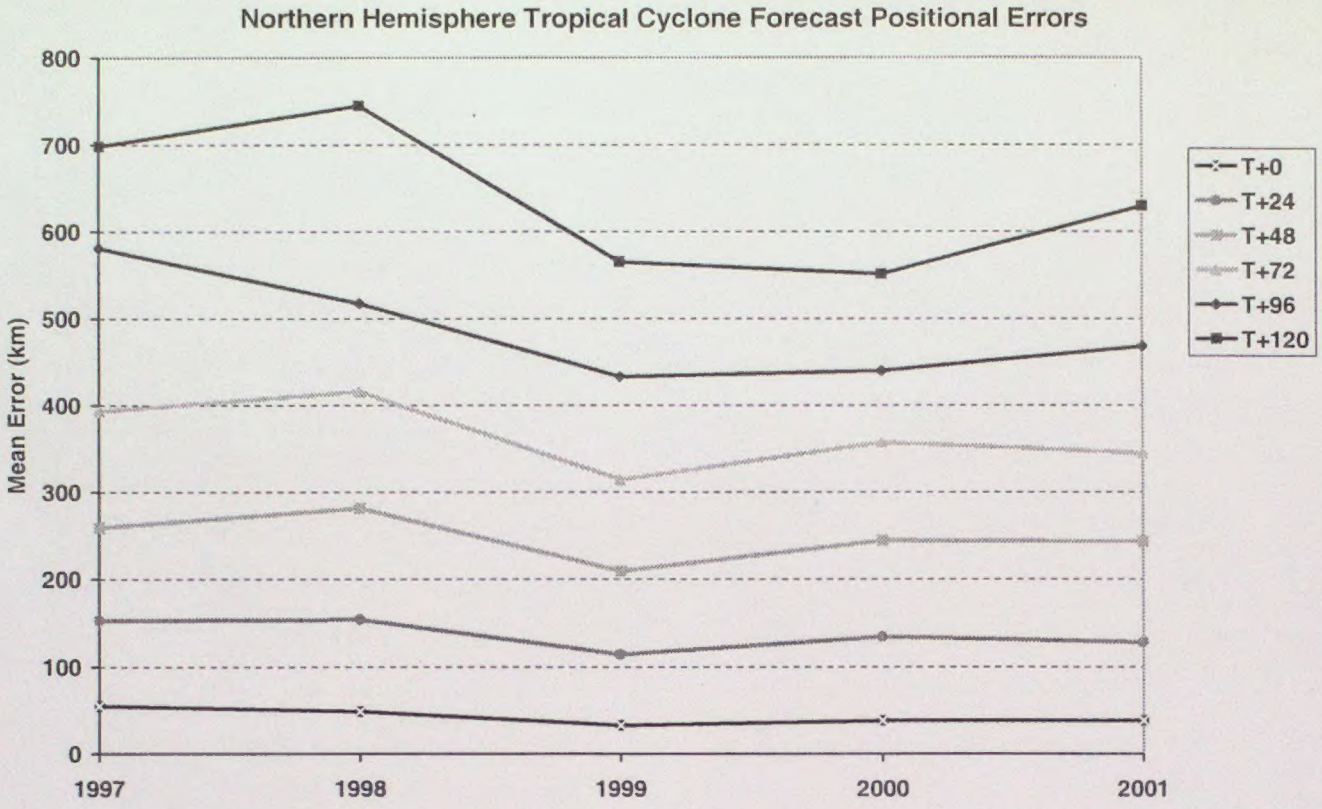
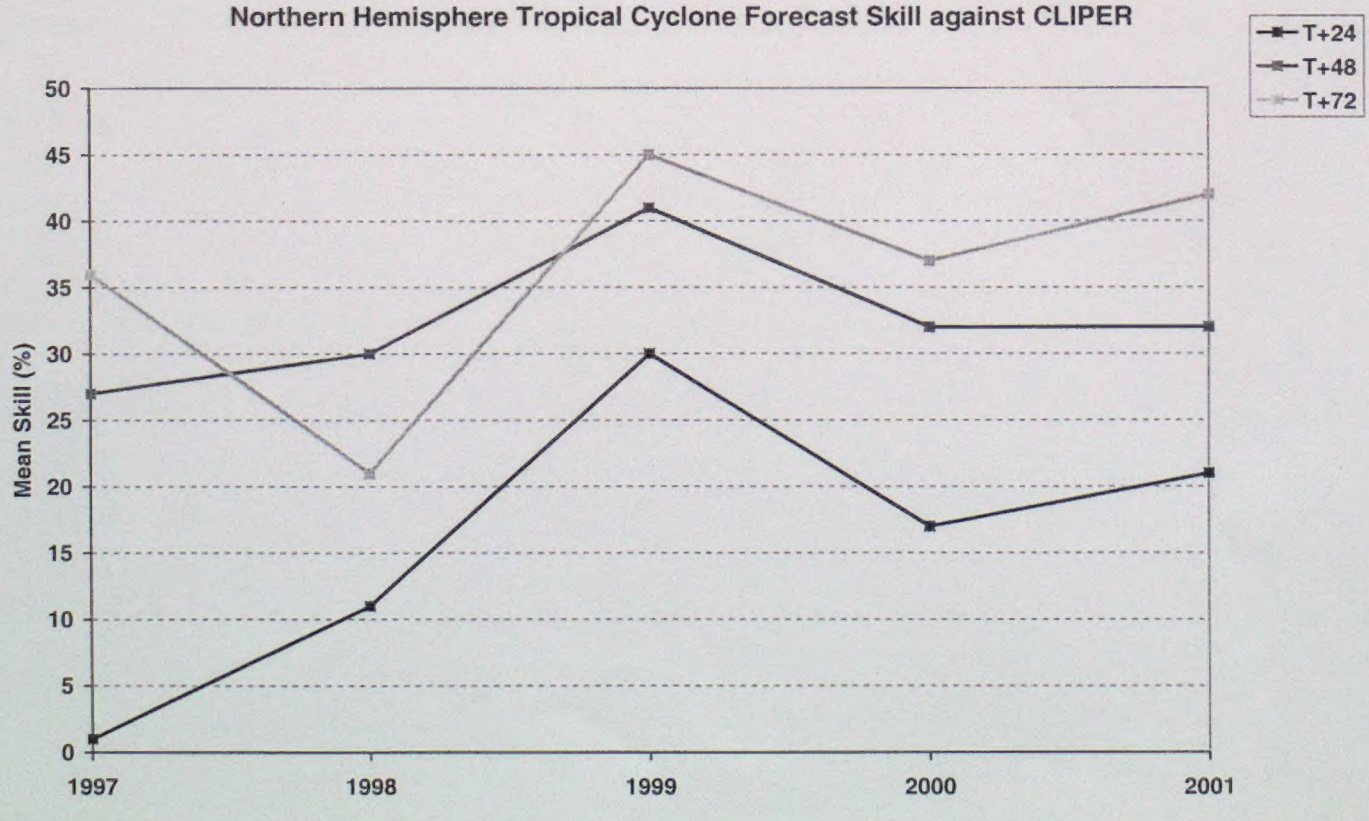



Figure 14



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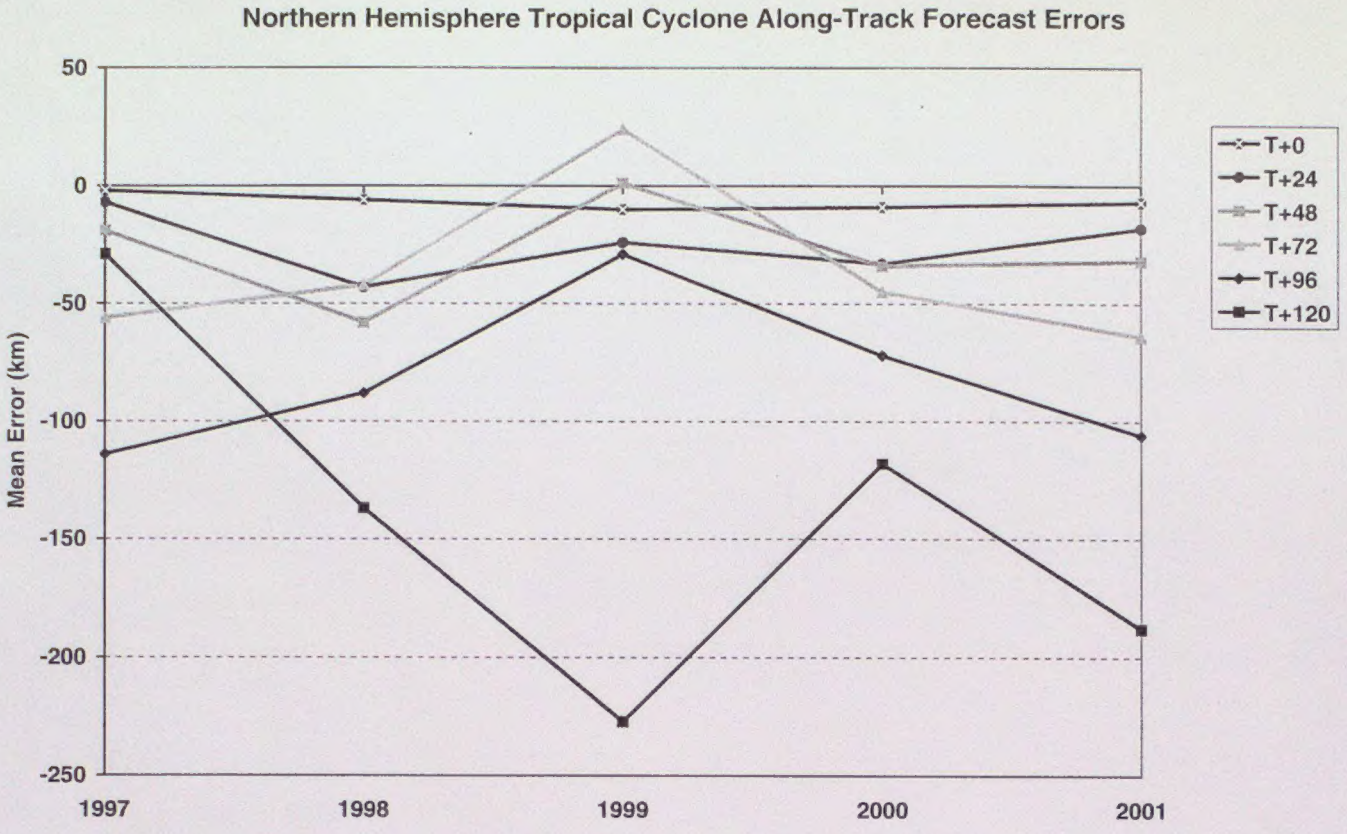

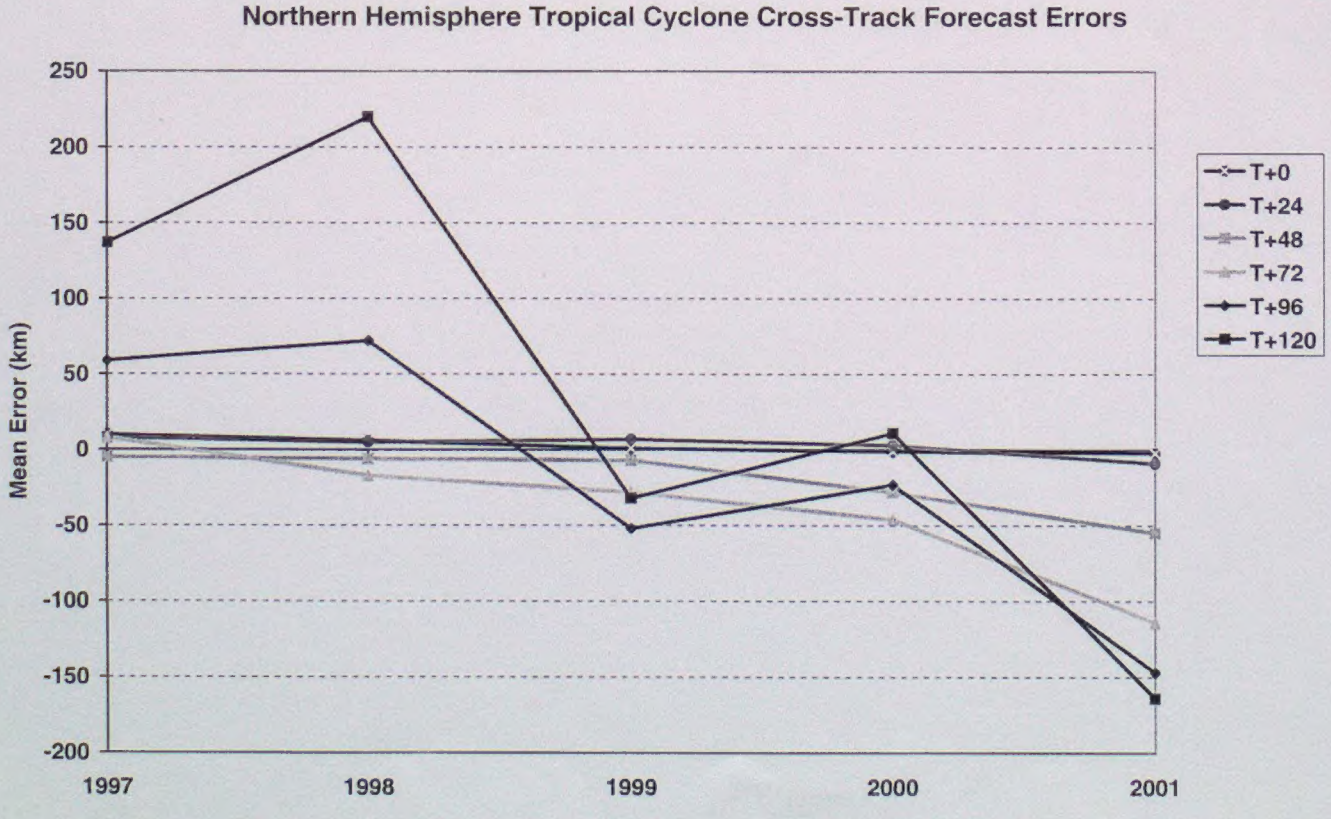
Figure 16